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ECONOMIC ANALYSIS OF EFFLUENT GUIDELINES RUBBER PROCESSING INDUSTRY

ARTHUR D. LITTLE, INCORPORATED

PREPARED FOR
ENVIRONMENTAL PROTECTION AGENCY

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An initial analysis of the economic impact of proposed water effluent guidelines upon the Rubber Processing Industry (SIC #2822 and SIC #3011) was performed, based on the abatement cost data supplied by EPA. On this basis, with better than 88% coverage of the industry, none of the plants appears to be severely affected in meeting either the B.P.T. or B.A.T. requirements. For the Synthetic Rubber segment, capital investment for pollution control will be an estimated $23 million through 1977, and $10 million from 1977 through 1983. Annual operating costs will be $8 million higher through 1977, and $4 million higher from 1977 through 1983. The Tire and Tube segment will meet both B.A.T. and B.P.T. in one step; investment will be an estimated $32 million, and annual operating costs will be roughly $13 million higher through 1977. The impact on prices will be no greater than 1.5% for B.P.T. and B.A.T. for the Synthetic Rubber segment, and about 0.45% for the Tire and Tube segment.

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ECONOMIC ANALYSIS
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EFFLUENT GUIDELINES

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U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Planning and Evaluation
Washington, D.C. 20460

EPA-230/2-74-024

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PREFACE

The attached document is a contractor's study prepared with the supervision and review of the Office of Planning and Evaluation of the U.S. Environmental Protection Agency (EPA). Its purpose is to provide a basis for evaluating the potential economic impact of effluent limitations guidelines and standards of performance established by EPA pursuant to sections 304(b) and 306 of the Federal Water Pollution Control Act.

The study supplements an EPA technical "Development Document" issued in conjunction with the promulgation of guidelines and standards for point sources within this industry category. The Development Document surveys existing and potential waste treatment and control methods and technologies within this category and presents the investment and operating costs associated with various control technologies. This study supplements that analysis by estimating the broader economic effects (including product price increases, continued viability of affected plants, employment, industry growth and foreign trade) of the required application of certain of these control technologies.

This study has been submitted in fulfillment of Contract No. 68-01-1541, Task No. 3 by Arthur D. Little, Inc. Work was completed as of August 1, 1974. The study is based primarily upon an earlier study, also prepared by Arthur D. Little, Inc., entitled "Economic Analysis of Proposed Effluent Guidelines for Rubber Processing Industry." The earlier report was circulated in conjunction with the publication of the Federal Register of a notice of proposed rulemaking under sections 304(b) and 306 for the subject point source category. The analysis contained in the original study has been updated based upon information received during the period of time between publication of the notice of proposed rulemaking and the promulgation of the final regulation. Because of the constraints of time, the control and treatment costs analyzed in this study may not in all instances be identical to those associated with the requirements of the promulgated regulation. However, those differences, when they exist are minor insofar as the final conclusions of the study are concerned.

This report represents the conclusions of the contractor. It has been reviewed by the Office of Planning and Evaluation and approved for publication. Approval does not signify that the contents necessarily reflect the views of the Environmental Protection Agency. The study has been considered, together with the Development Document, information received in the form of public comments on the proposed regulation, and other materials in the establishment of final effluent limitations guidelines and standards of performance.

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EXECUTIVE SUMMARY

Introduction

The objective of this study is to provide an analysis of the economic impact of the water pollution control requirements anticipated under the Federal Water Pollution Control Amendments of 1972. The impact was analyzed for three levels of treatment:

- Best Practicable Technology available (B.P.T.) – to be met by industrial dischargers by 1977.
- Best Available Technology economically achievable (B.A.T.) – to be met by 1983.
- New Source Performance Standards (N.S.P.S.) – to be applied to all new facilities that discharge directly to navigable waters and constructed after the promulgation of guidelines.

Specifically the economic impacts analyzed are:

- Price
- Profitability, growth and capital availability
- Employment
- Community
- Balance of Payments
- Related Industries

Methodology

In determining the effects of pollution control on the industry, an estimation was made of the costs that would be likely to be incurred, based on the effluent guidelines document and information received from the industry. Conclusions were drawn from an analysis of the way in which these costs would affect prices, production, employment, profits and other economic variables, based on a 70-100 percent coverage of the manufacturing facilities associated with each category.

It was assumed the increased costs will be passed on in the form of higher prices to maintain the companies' historical return on stockholders' equity. Most of the plants were assumed to be working at their 1972 capacity, except EPDM, which will expand to 80-85 percent of current 1972 capacity by 1977. The industry demand curves for these products are assumed essentially inelastic; there are no substitutes (other than natural rubber) for most of the rubber products.

Segmentation

The synthetic rubber industry has been segmented by product rather than by process, and tires and tubes was considered as a separate segment. Because of market and price considerations, this segmentation was more useful in considering economic impact.

Financial Considerations

The costs associated with meeting the Best Practical Technology and Best Available Technology Economically Achievable were determined for the various segments of the industry. The investment, annualized costs and estimated price increases as a percent of sales are summarized in Tables 1 and 2, averaged for the synthetic rubber and tire and tube segments.

Impacts

These additional costs are not expected to exert a significant impact on the market and prices of the respective products. It is not expected that any plants will be closed in either the synthetic rubber or tire and tube segments. However, industry sources in the tire and tube segment of the study indicate there may be a short period of plant shutdown, particularly in the older plants, while changes are made in order to segregate their effluent lines.

This analysis indicates no adverse effects on the growth of the industry due to B.P.T., B.A.T., and N.S.P.S. In addition, the costs should not significantly affect either the domestic market competitiveness or the international market situation -- the dollar devaluation far overshadows the insignificant price increases involved. However, it is impossible to know what the strength of the United States dollar will be in 1977 and 1983.

Limitations

When interpreting the findings of this study, it is important to be aware of the limitations of the cost data used for calculating investment and annual operating costs. Specifically, the conclusions in this study are based on the guidelines as proposed in the Effluent Guideline Development Document, the associated technology to meet these limits, and the related cost. If the assumptions in deriving these costs or the effluent requirements are changed as to require different technologies, then the conclusions of this study may not necessarily be valid. We believe that this analysis as presented represents an accurate description of the economic effect of the cost of pollution on this industry. The calculated price increases for pollution guidelines (B.A.T. and B.P.T.) are maximum expected increases. Certain companies and certain plants meet B.P.T. guidelines and may not increase their prices at all. Other companies may be constrained to follow suit.

TABLE 1

THE SYNTHETIC RUBBER INDUSTRY

SIC Code: 2822

	A. Butyl, EPDM, Neoprene, Nitrile, Polybutadiene, Polyisoprene, SBR Emulsion + Solution			B. Latex		
	No. of operations specifically evaluated for B.P.T. = 36 (90% of industry), for B.A.T. = 39 (98% of industry)			No. of operations specifically evaluated for B.P.T. = 6 (26% of industry), for B.A.T. = 6 (27% of industry)		
Impacts	**B.P.T.**	**B.A.T.**	**N.S.P.S.**	**B.P.T.**	**B.A.T.**	**N.S.P.S.**
Costs						
Investment						
Total for segment	$22.5 x 10^6	$9.90 x 10^6	–	3.6	1.8	–
Per plant (average)	$625,000	$254,000	–	0.6	0.3	–
Percent of average annual investment in segment	N.A.	N.A.		N.A.	N.A.	
Annual						
Total for segment	$7.94 x 10^6	$4.40 x 10^6	–	1.21	0.56	–
Per plant average	$221,000	$114,000	–	0.20	0.19	–
Percent of sales	0.8%	0.7%	–	3.2	1.5	–
Price increase (varies from product to product)	0-1.5%	0-1.5%	–	0-2.1	0-2.2	–
Plant closings	0	0	–	0	0	–
Percent of total in segment	0	0	–	0	0	–
Displaced workers	0	0	–	0	0	–
Percent of total in segment	0	0	–	0	0	–
Number of community impacts	0	0	–	0	0	–
Impact on industry growth	None	None	None	None	None	–
Direct balance of payment effects	None	None	None	None	None	–

TABLE 1

THE SYNTHETIC RUBBER INDUSTRY

SIC Code: 2822

	A. Butyl, EPDM, Neoprene, Nitrile, Polybutadiene, Polyisoprene, SBR Emulsion + Solution			B. Latex		
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Impacts	**B.P.T.**	**B.A.T.**	**N.S.P.S.**	**B.P.T.**	**B.A.T.**	**N.S.P.S.**
Costs						
Investment						
Total for segment	$22.5 x 10^6	$9.90 x 10^6	–	3.6	1.8	–
Per plant (average)	$625,000	$254,000	–	0.6	0.3	–
Percent of average annual investment in segment	N.A.	N.A.		N.A.	N.A.	
Annual						
Total for segment	$7.94 x 10^6	$4.40 x 10^6	–	1.21	0.56	–
Per plant average	$221,000	$114,000	–	0.20	0.19	–
Percent of sales	0.8%	0.7%	–	3.2	1.5	–
Price increase (varies from product to product)	0-1.5%	0-1.5%	–	0-2.1	0-2.2	–
Plant closings	0	0	–	0	0	–
Percent of total in segment	0	0	–	0	0	–
Displaced workers	0	0	–	0	0	–
Percent of total in segment	0	0	–	0	0	–
Number of community impacts	0	0	–	0	0	–
Impact on industry growth	None	None	None	None	None	–
Direct balance of payment effects	None	None	None	None	None	–

TABLE 2

THE TIRE AND TUBE INDUSTRY

SIC Code: 3011
Number of plants specifically evaluated: 49
Percent of total plants: 88%

Impacts	B.A.T. 1977 Standards	= ≡	B.P.T. 1983 Standards	N.S.P.S. New Source Standards
Cost				
Investment				
Total for segment	$31.5 x 10^6			–
Per plant (average)	$790,000			–
Percent of average annual investment in segment	N.A.			–
Annual				
Total for segment	$12.56 x 10^6			–
Per plant (average)	$310,000			–
Percent of sales	0.3%			–
Price increase	0-0.45%			–
Plant closings	0			–
Percent of total in segment	0			–
Displaced workers	0			–
Percent of total in segment	0			–
Number of community impacts	impossible to evaluate			–
Impact on industry growth	None			None
Direct balance of payments effects	None			None

INDUSTRY SEGMENTATION

The segmentation of the rubber processing industry used by the Contractor differs from that described in the effluent guidelines development document. In the guidelines document, industry segmentation was based on technical considerations such as the quantity, characteristics, and applicability of control and treatment to the wastewater generated by the specific pl. its. The technical segmentation of the synthetic rubber industry was based on manufacturing processes. Basically, there are two processes in common use in the industry: emulsion polymerization and solution polymerization. Emulsion polymerization is used to produce both emulsion crumb rubber (dry form) and latex rubber (water-suspended form). According to the effluent guideline development document, however, crumb and latex production should be considered separately both from operational and wastewater points of view. Solution polymerization plants are different from emulsion facilities not only in terms of process, but also in terms of the quantity and character of the wastewater. As a consequence, three segments based on manufacturing process variations were specified in the guideline document: emulsion polymerization to form crumb rubber, solution polymerization to form crumb rubber, and emulsion polymerization to form latex.

For the tire and inner tube industry, the guidelines document used age of the production facility as the basis for segmentation. In the effluent guideline development document, it is stated that plants built prior to 1959 tend to be multi-storied, with production lines located on many floors and confined to small areas. In such plants, process, non-process, and domestic wastewater are combined in a common sewer, thus making process contaminants difficult to locate and treat. The document states that the newer plants have the benefit of modern design criteria in both the sanitary and maintenance engineering fields. Sewers are no longer combined, thus making process sewer wastewaters easier to locate and treat. As a consequence, the process wastewater streams from these post-1959 plants are generally smaller in volume and contain lower loadings of both oily and solid materials – thus making treatment less costly than for older plants with similar production.

The technical segmentation used in the guideline documents is useful for categorizing processes and pollution, but it is not appropriate for assessing the economic impact of pollution control costs. An assessment of the economic impact of pollution control must take into account the financial and economic characteristics of the business, and similarities in technology do not imply similarities in business.

Therefore, to permit an analysis of how pollution control costs would affect production, employment, profits, prices, and other economic variables that are critical to an industry, the Contractor segmented the synthetic rubber industry by product. The tire and inner tube industry were treated separately. The relationship between segmentation used by the contractor and that used in the guidelines is shown in Table 3.

TABLE 3

COMPARISON OF ECONOMIC AND TECHNICAL SEGMENTATION

Industry	Economic	Technical
Synthetic Rubber	Neoprene	Emulsion crumb
	Nitrile	
	Polybutadiene	
	Styrene-butadiene (SBR)	
	Butyl	Solution crumb
	EPDM	
	Polybutadiene	
	Polyisoprene	
	Styrene-butadiene (SBR)	
	Styrene-butadiene (SBR latex)	Latex
	Nitrile latex	
Tires and Inner Tubes	Tires and inner tubes	Old tire and inner tube
		New tire and inner tube

Plant Locations

An analysis of plant locations for the manufacture of synthetic rubbers and tires and tubes shows they are located in heavily industrialized areas. In the case of synthetic rubber they are located near sources of raw materials and refineries. Figure 1 shows the locations of the different plants.

A

FIGURE 1 LOCATION OF SYNTHETIC RUBBER AND TIRE AND INNER TUBE PLA

CATION OF SYNTHETIC RUBBER AND TIRE AND INNER TUBE PLANTS (1972)

DESCRIPTION OF SYNTHETIC RUBBER INDUSTRY SEGMENTS

Butyl Rubber-Solution

Technology. Butyl rubber is a copolymer of isobutylene and isoprene and contains 1.4% to 4.5% of isoprene. The rubber is prepared by polymerization in an organic solvent, using aluminum chloride as the catalyst. After polymerization, the rubber, which is in the form of a finely divided slurry, is recovered by vaporizing the organic solvent with hot water and steam. The resulting aqueous slurry of rubber crumb is dewatered and dried by the methods used for the other synthetic rubbers.

Plant Location, Sizes and Ages. There are only two domestic producers of butyl rubber, Exxon and Cities Service's Columbian Carbon Division. Exxon operates two widely diversified facilities, one at Baton Rouge with a capacity of 46,000 lt/year, and the other at Baytown, Texas, with a capacity of 80,000 lt/year. Synthetic rubber operations in these plants began during World War II. Cities Service began operating their Lake Charles, La., facility in 1963. They report a capacity of 37,500 lt/year.

Uses. About 80% of total production is used in tires and tire products. This application is expected to continue to show slow but steady increase. The use of butyl in adhesives and sealants is growing well in excess of the overall market but is still small.

Ethylene-Propylene Elastomers-Solution

Technology. Ethylene-propylene elastomers (EP) are synthetic polymers prepared by the solution copolymerization of ethylene and propylene. Two basic forms of the rubber are produced, EPM (a saturated, peroxide vulcanizable polymer) and EPDM (an unsaturated conventional sulfur curable polymer). EPDM accounts for about 95% of the total production of ethylene-propylene elastomers, and has been used by the Contractor to represent the entire class of EP elastomers.

Plant Locations, Sizes and Ages. Five plants operated by five different companies are engaged in the production of EPDM. These plants are located in Louisiana (3) and Texas (2), and range from 25-56,000 long tons of annual production capacity. All the plants were built between 1963 and 1971.

Uses. Table 4 illustrates the variety of end-use markets in which EPDM is used:

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TABLE 4

MARKETS

	Percent of Domestic Consumption
Automotive Parts (non-tire)	35.0%
Tires and Tire Products	32.0
Wire and Cable Insulation	7.0
Appliance Parts	6.5
Hoses	6.0
Gaskets, Seals, and O-Rings	4.5
Coated Fabric and Sheeting	2.0
Other	7.0
	100.0%

Source: Chemicals Economic Handbook, Stanford Research Institute, May 1972.

Since the introduction of EPDM in 1963, the forecast of demand for the rubber has consistently exceeded actual demand. As a result production in 1972 averaged only about 50% of capacity. This excess capacity has created a marketing environment where the rubber price is often discounted 10-20% below list (28-30¢/lb).

However, despite excess capacity, some producers say that EPDM supplies are tight. They explain that they now produce so many different types and grades of the elastomer that their effective capacity is reduced.

New emphasis in automotive safety and pollution control equipment has boosted demand for EPDM for such applications as bumpers and high-temperature-stable hoses and belts. These and other growing markets are causing domestic consumption to grow at a brisk 10-15% per year.

Neoprene-Emulsion

Technology. Neoprene is one of the oldest synthetic rubbers in existence – having been first introduced on a commercial scale in 1931 by Du Pont. Until relatively recently, neoprene was made commercially from chloroprene monomer produced from acetylene feed stock. Today, a more economical butadiene route to the monomer is being utilized.

Plant Locations, Sizes, Ages. Only two companies in the United States – Du Pont and Petro Tex – make neoprene.

Du Pont presently operates two neoprene plants. The Louisville, Kentucky, facility, with a capacity for 125,000 lt/year, is a diversified complex, most of which was constructed during World War II. The chloroprene monomer used here is supplied from a newly constructed plant in Victoria, Texas.

Du Pont's facility in La Place, La., produces both chloroprene monomer and neoprene, with a neoprene capacity of 40,000 lt/year. This facility went on-stream in 1970.

Petro Tex's Houston plant went on-stream in 1970. Its capacity is estimated at 44,000 lt/year. The Houston facility also contains Petro Tex's butadiene monomer facility, one of the largest in the United States.

Uses. Automotive products (fan belts, hosing, etc.), account for about 45% of market; industrial/aerospace/consumer products (conveyor belts, wet suits, etc.), about 20%; wire and cable, 10% and declining; adhesives, 12% with an annual growth rate of 10%. The remaining 13% is used in a variety of other products, none of which is large enough to be of interest.

Nitrile-Emulsion (Crumb and Latex)

Technology. Nitrile rubber, a copolymer of acrylonitrile and butadiene, is produced by emulsion polymerization in a manner similar to that used in making emulsion SBR. The basic steps involved in the manufacture of dry rubbers are polymerization, coagulation, washing and drying. If a latex is desired, the steps are polymerization, stabilization, and usually concentration.

Plant Locations, Sizes, Ages. Six companies produce nitrile rubber in nine plants; one is located in Delaware, one in Kentucky, two in Louisiana, four in Ohio, and one in Texas. Nitrile plants have the smallest production capacity of all the plants in the synthetic rubber industry, exhibiting an average annual capacity of less than 15,000 long tons.

Most of these plants were built before or during World War II, and very little new technology has been developed since then.

Uses. Because of its outstanding resistance to oil and solvent, nitrile rubber is utilized for a number of "under-the-hood" automotive applications; these account for about 25% of all nitrile produced. Other applications include mechanical goods, belting, rollers, etc.

Polybutadiene-Solution/Emulsion

Technology. Polybutadiene, a homopolymer of butadiene, accounts for 12% of total U.S. synthetic rubber production.

In the commercial production of polybutadiene elastomers, the exact nature of the final product depends on several factors, the most important of which are the catalyst system and the reaction medium (solution or emulsion polymerization).

Only one plant – Texas-U.S. in Port Neches, Texas – produces polybutadiene by the emulsion process. This plant accounts for less than 10% of the domestic capacity for the production of polybutadiene. The remainder is accounted for by six other polybutadiene plants producing the rubber by solution polymerization.

Plant Locations, Sizes and Ages. At the present time there are seven plants producing polybutadiene: one in Louisiana, one in Kentucky, and five in Texas.

There is quite a variation in plant size with the smallest having a capacity of about 20,000 long tons, the largest 110,000 long tons, and the average being about 64,000 long tons.

The polybutadiene plants are relatively new, having been built between 1961 and 1963. From 1965 to 1968, the plants increased their capacity at a rate of about 16% per year, through new construction. Over the last years the rate of growth has slowed to about 13.5% per year. The ability to meet increasing demand has been the result of both new construction and the "debottlenecking" of existing operations (primarily in the drying and finishing areas).

Polyisoprene-Solution

Technology. Polyisoprene elastomers are synthetic, predominantly stereoregular, polymers which closely resemble natural rubbers in both molecular structure and properties. Two basic types are currently being produced: cis-polyisoprene and trans-polyisoprene.

Cis-polyisoprene is used in many of the same applications as natural rubber: tires and tire products, foam rubber, hoses, gloves, etc.

Trans-polyisoprene, on the other hand, has quite different properties and is used in specialty applications such as golf ball covers, cable and wire covering, and adhesives.

All polyisoprene elastomers are produced by solution polymerization, in a manner quite similar to that used to produce polybutadiene. The polymers are sold both in dry rubber and latex form.

Plant Locations, Sizes, and Ages. There are two polyisoprene plants. The first was built by Goodyear in Beaumont, Texas in 1962. This plant has a capacity of 62,000 long tons. The second was built by Goodrich in Orange, Texas in 1968. The Goodrich plant has a capacity of 62,500 long tons.

Uses. The growth of polyisoprene demand has been slow. However, it is believed that a more general acceptance of radial ply tires in the United States would very likely increase the demand for polyisoprene, since good building tack and green strength -- qualities of natural rubber -- are essential in the construction of radial ply tires. Because of its similarity to natural rubber, polyisoprene could become the logical replacement for this application.

SBR-Emulsion/Solution

Technology. SBR, a copolymer of styrene and butadiene, typically contains about 25 parts styrene to 75 parts butadiene. SBR accounts for over 60% of all the synthetic rubber manufactured in the United States.

Most of the SBR produced is manufactured by the so-called cold emulsion process which was developed just after World War II and is used with few modifications even today. Most process modifications have been concerned with alleviating bottlenecks in the polymerization, drying and finishing operations and with increasing the volume produced through extension of the rubber with oil and carbon black. The same basic process is used to produce both dry rubber and latex (a suspension of SBR in water).

An alternative to the emulsion process is a solution process used by Firestone Tire & Rubber Company, and Phillips Petroleum, Co. Solution SBR exhibits better abrasion and crack resistance than emulsion SBR, but at present is priced 10-15% higher than the emulsion type.

As far as water pollution is concerned, the emulsion process is by far the more troublesome. Water is used as the suspending medium during the polymerization, and it must ultimately be removed to produce dry rubber.

Plant Locations, Sizes, and Ages. The plants in which SBR is made are located either adjacent to butadiene-producing plants or near the markets. For example, during World War II, SBR plants using butadiene derived from petroleum were located in Louisiana, Texas, and California; those using butadiene made from alcohol were located in West Virginia, Pennsylvania, and Kentucky. Those serving specific markets were located in Ohio and Connecticut. At the present time there are eleven plants producing emulsion crumb SBR, with an average annual production capacity of over 140,000 long tons. However, the plants are by no means of uniform size, exhibiting a range of capacity from 28,000 long tons to 410,000 long tons.

The newest plant was built in 1957, while the others were built between 1941 and 1945.

Uses. An estimated 65-70% of SBR production goes to the tire industry; 7-8% goes for mechanical goods, 9% for exports, 1-2% for footwear, and 12% for miscellaneous products.

Growth in demand for emulsion SBR has slowed to 1-3%/year reflecting the mature status of this 30-year-old product.

SBR-Latex

Introduction. Most SBR is sold as dry rubber; however, about nine percent of the production is sold in latex form. In many specialty products, the styrene and butadiene ratio is varied. Very limited information is available on this segment of the industry.

Technology. SBR latex, a copolymer of styrene and butadiene, is produced by the same polymerization process used in the manufacture of SBR crumb rubber. The steps required to produce a latex are polymerization followed by stabilization and usually concentration.

Plant Locations, Sizes and Ages. Fifteen companies presently produce SBR latex in 23 plants located in 14 different states. The production capacity of the 12 plants for which data are available ranges from 5,000 to 35,000 long tons per year.

Plants vary widely in age. The older plants date from World War II; the latest plant was built in 1972.

Uses. SBR latex is used primarily in carpet backing, dipped rubber goods and adhesives.

Approximately 15% of the 1972 U.S. production (158,000 long tons) was exported.

Growth in demand for SBR latex is less than that of most other latices and is expected to be less than 4% per year through 1975 (*Chemical and Engineering News*, 8/21/72).

Summary of U.S. Synthetic Rubber Capacity

Table 5 lists the synthetic rubber production in the plants of concern in this study. Of the 28 plants listed here, 18 produce only one rubber type, 9 produce two types, and one plant produces three different rubber types. In addition, most of the 18 plants producing a single rubber are part of diversified plant complex manufacturing other products such as rubber processing chemicals, plastics, and basic and intermediate organic chemicals. As a consequence, the wastewater effluent from the synthetic rubber operations is generally combined with other plant effluents and treated in a common facility. The implication of this common treatment in regard to pollution cost allocation to the individual products is covered in a later section of this document.

TABLE 5

CAPACITY OF U.S. SYNTHETIC RUBBER PLANTS

Company Name	Location	Production Capacity						
		Butyl	EPDM	Neoprene	Nitrile	Polybutadiene	Polyisoprene	SBR
American Synthetic Rubber	Louisville, Ky.					75,000		125,000
Ashland	Baytown							80,000
Cities Service	Lake Chas., La.	37,500						
Copolymer	Addis, La.		25,000					
	Baton Rouge, La.				5,500			127,000
DuPont	Beaumont, Tex.		56,000					
	La Place, La.			40,000				
	Louisville, Ky.			125,000				
Exxon	Baton Rouge, La.	46,000	35,000					
	Baytown, Tex.	80,000						
Firestone	Akron, Ohio				2,500			50,000
	Lake Chas, La.					20,000		230,000 emuls.
								23,000 sol.
	Orange, Tex.					75,000		
Gen. Tire	Odessa, Tex.							110,000
Goodrich	Akron, Ohio				35,000			
	Louisville, Ky.				35,000			
	Orange, Tex.		25,000			87,000	62,500	
	Port Neches, Tx.							178,000
Goodyear	Akron, Ohio				11,000			
	Beaumont, Tex.					110,000	65,000	
	Houston, Tex.				11,000			410,000
Petrotex	Houston, Tex.			44,000				
Phillips	Borger, Tex.					50,000		77,000 emuls.
								2,300 sol.
Texas-US	Port Neches, Tex.					30,000		148,000
Uniroyal	Baton Rouge, La.				15,500			
	Geismar, La.		50,000					
	Naugatuck, Conn.							28,000
	Painesville, Ohio				15,500			

DESCRIPTION OF THE TIRE AND TUBE INDUSTRY

Fifty-six plants in the United States produce tire and tube products. Of these, 40 are operated by Firestone, General Tire, Goodrich, Goodyear and Uniroyal.

Technology

The technology of the production of tires is very similar in all plants. Basically, the raw rubber is compounded with oil, carbon black and various curing ingredients. The compound is then calendered onto fabric which forms the tire plies. Special tough stocks are made into tread stock and sidewall stock and are extruded to shape. The tire is then built up on a drum, one kind of drum for bias and belted bias tires, and another for radial tires.

In recent years each change in tire structure has resulted in more costly tires with better wear and stability. Tread wear has been increased by 50% in going from the bias to the belted bias, and by another 50% in going from the belted bias to the radial tire. Thus the radial tire can be expected to provide from 40,000 miles of tire life versus 20,000 miles for the conventional bias tire.

The change from bias to belted tires took place between 1968 and 1970 and required a major investment by the tire companies for new equipment. A rough rule of thumb for switching to radials (as companies are now doing) is that for a 10,000-passenger-tires-per-day plant, an additional investment of about $7-8 million will be required. If there is a 60% replacement to radials in the seventies, this will require a $280 million dollar investment by the industry.

Plant Size

Tire plants vary widely in capacity; the largest produce some 30,000 tires per day, and the smaller ones less than 5,000 per day. Production depends to a great extent on the tire mix. For example, the building of a passenger car tire requires about one minute, while many off-the-road tires require as long as an hour.

Plant Age and Location

The specific problems of pollution control depend in part on the age and general upkeep of the plant because much of the pollution comes from washdown of facilities and blowdown of cooling water. However, most tire plants have been expanded and modernized since 1967, when the belted bias tires went into production.

Table 6 lists the tire plants and their location. The Akron area is a heavily built-up industrial section with little land available for water treatment facilities. Newer plants are located in less confining areas where sufficient land is generally available for ponds and lagoons.

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TABLE 6

TIRE PRODUCERS AND PLANT LOCATIONS

Company	Headquarters	Plant Locations and Annual Passenger Car Tire Production (number of tires)
Armstrong Rubber	W. Haven, Conn.	W. Haven, Conn.; Natchez, Miss.; Des Moines, Iowa; Hanford, Calif. Total Production 14,700,000
Carlisle Rubber	Carlisle, Pa.	Carlisle, Pa. Total Production approx. 1,200,000
Cooper Tire & Rubber	Findlay, Ohio	Findlay, Ohio; Texarkana, Arkansas, Mississippi Total Production, 8,000,000
Dunlop Tire & Rubber	Buffalo, N.Y.	Buffalo, New York Total Production 2,000,000
Firestone Tire & Rubber	Akron, Ohio	Akron; Des Moines; Los Angeles; Memphis; Nashville; Noblesville, Indiana; Pottstown, Pa.; Dayton Barberton, Ohio; Oklahoma City Total Production 49,100,000
Gates Rubber	Denver	Denver; Nashville Total Production 7,500,000
General Tire & Rubber	Akron	Akron; Mayfield, Kentucky; Waco, Texas; Byran, Ohio; Charlotte, N.C. Total Production 12,300,000
Goodrich	Akron	Akron; Ft. Wayne; Los Angeles; Miami; Oklahoma; Tuscaloosa, Alabama; Valley Forge, Pa. Total Production 21,400,000
Goodyear	Akron	Akron; Gadsden, Alabama; Conshohocken, Penn; Jackson, Michigan; Los Angeles; St. Mary's, Ohio; Topeka, Kansas; Cumberland, Maryland Fayetteville, N.C.; Union City, Tenn.; Freeport, Ill.; Tylor, Texas. Total Production 57,950,000
Mansfield Tire & Rubber	Mansfield, Ohio	Mansfield, Ohio Total Production 3,000,000
McCreary Tire & Rubber	Indiana, Penn.	Indiana, Pennsylvania Total Production 2,500,000
Mohawk Rubber	Akron	Akron; West Helena, Arkansas Total Production 6,000,000
Uniroyal	N.Y.C.	Detroit; Eau Claire, Wisconsin; Indianapolis; Los Angeles; Ardmore, Oklahoma; Opelika, Alabama, Springfield, Massachusetts Total Production 32,000,000

FINANCIAL PROFILES

Most manufacturers are large firms with a high level of integration, and most are committed to the manufacture of synthetic rubber products. The financial position of these companies is relatively strong.

There are, however, a few small producers of synthetic rubber, some of which are owned by the petroleum industry, and some of which are not involved in the manufacture of consumer rubber products. These producers would probably shut down if costs increased significantly.

In 1972 the synthetic rubber industry shipped 5,650 million pounds of rubber, having an estimated value of $1.1 billion. Customers for synthetic rubber are mostly manufacturers of components for transportation equipment. While this market has been expanding, synthetic rubber shipments are increasing only moderately because of depressed prices and substitution of plastics for rubber in non-tire uses. Table 7 gives a profile of the synthetic rubber industry in 1972. In 1973, in spite of the energy crisis the amount of synthetic rubber shipped increased. Unless the crisis reoccurs, shipments are expected to continue to increase, but the outlook is uncertain because shipments are contingent on so many factors. The value of shipments in 1973 and 1974 (estimated) was $1260 and $1315 million, respectively.

TABLE 7

1972 PROFILE – SYNTHETIC RUBBER

SIC Code	2822
Value of industry shipments (million)	$1,125
Number of establishments	50*
Total employment (thousands)	13
Exports as percent of product shipments	12.8
Imports as percent of apparent consumption	4.6
Compound annual average rate of growth 1967-72 (percent):	
Value of shipments (current dollars)	3.9
Value of exports (current dollars)	0.7
Value of imports (current dollars)	19.9

*Contractor data shows 56 plants

Source: Bureau of Domestic Commerce.

In 1972, the tire industry produced 225 million tires and tubes, valued at an estimated $4.8 billion. Rising business activity and growth in new car sales have been providing impetus to the growth of tire shipments. Original equipment tires on new cars jumped from 38 million tires in 1970 to 49 million in 1971 and to 54 million in 1972. Replacement tires

have grown from 129 million tires in 1969 to 135 million in 1971 and to 142 million in 1972. The energy crisis, reduced new car sales, and the shift to radials all have a tendency to reduce the number of tires produced. Despite this, there has been an increase during 1973 and 1974 in number of units sold and in dollar volume of sales. The value of shipments in 1973 and (estimated) for 1974 is $6,440 and $6,960 million, respectively. The following trends can be anticipated:

> If O.E.M. requirements are reduced, replacement tire sales will increase as old cars are driven longer. The increased cost of radials will offset dollar volume loss as the number of tires consumed is reduced.
>
> The proportion of rubber used for tires versus non-tire uses can be expected to be reduced.

Longer lasting tires are extending the traditional two-year replacement cycle, Growth in snow tire demand has slowed, reflecting maturity in the market. Table 8 gives a profile of the tire and inner tube industry for 1972.

TABLE 8

1972 PROFILE – TIRES AND INNER TUBES

SIC Code	3011
Value of industry shipments (millions)	$5,625
Number of establishments	200*
Total employment (thousands)	115
Exports as a percent of product shipments	2.0
Imports as a percent of apparent consumption	8.2
Compound annual average rates of growth 1967-72 (percent) :	
Value of shipments (current dollars)	8.6
Value of exports (current dollars)	6.5
Value of imports (current dollars)	36.8

*Total includes contributions of recappers and tire related products.

Source: Bureau of Domestic Commerce.

The major producers of synthetic rubber and tires and tubes also produce plastics, and thus the two are considered together in reviews of financial performance. Table 9 shows financial performance of manufacturers of rubber and plastic products from 1967 to 1972.

According to the *U.S. Industrial Outlook** published by the Department of Commerce, corporate profits after taxes, for manufacturers of rubber and plastics products, rose from

*U.S. Industrial Outlook; U.S. Department Commerce.

TABLE 9

RUBBER AND PLASTICS PRODUCTS: FINANCIAL RATIOS 1967-72
(Percent)

	1967	1968	1969	1970	1971	First Half 1971	First Half 1972
Ratios:							
Profit after taxes/sales	4.0	4.5	3.8	2.8	3.6	3.5	4.1
Profit after taxes/investment	7.5	8.5	6.9	4.6	5.9	6.1	7.4
New capital expenditures/gross plant	8.7	10.3	9.7	3.2	6.6	NA	NA
Depreciation/gross plant	6.8	6.2	5.8	6.0	5.8	6.1	6.2
Depreciation/sales	3.4	3.2	3.1	3.6	3.5	3.5	3.4
Sales/total assets	140	136	133	123	120	126	130

Note – NA – not available.

*U.S. Industrial Outlook; U.S. Department Commerce.

Sources: Federal Trade Commission, Securities and Exchange Commission, and Bureau of the Census.

$456 million in 1970 to $664 million in 1971 and to almost $900 million in 1972. Profits in 1970 were exceptionally low; ratios of profits to sales and to capital investment returned in 1972 to 4:5 and 7:5, about the levels of the mid-1960's.

"Because of the poor financial returns in 1970 and early 1971, new capital expenditures for plant and equipment dropped from $857 million in 1969 to $812 million in 1970 and to $726 million in 1971. Rising sales and improved operating ratios in 1972 resulted in a 33% increase in new capital expenditures to $970 million, the largest one-year increase ever recorded for the rubber and plastics industries. Most of the capital spending was for new tire plants to meet increasing demand for tires in general and radial tires in particular, plus new facilities for the rapdily growing plastic products industry." Table 10 gives financial profiles for the various industry segments in this report.

TABLE 10

1972 FINANCIAL PROFILE FOR SEGMENTS

Product	Estimated Price[1]	Relative Product Profitability[2]	Production as Percent of Capacity[3]	Anticipated Annual Rate of Growth for Next 5 Years[4]
Butyl	$0.25/lb	Moderate	80%	2-5%
E.P.D.M.	0.26	Variable	50%	5-15%
Neoprene	0.35	Moderate - High	87%	0-4%
Nitrile	0.45	Moderate - High	66%	3-7%
Polybutadiene	0.165	Low - Moderate	83%	3-5%
Polyisoprene	0.19	Low - Moderate	93%	5-8%
SBR	0.13	Low	85%	0-3%
Tires (general average)	21.24			
Tires (passenger car tires)	14.43	Moderate	85%	6-8%

1. The actual prices vary considerably depending on grade, type, and volume purchased. These figures only approximate the average prices and are based on U.S. Tariff Commission data, industry quotations, and Arthur D. Little, Inc., estimates.
2. Comments of industry spokesmen regarding profitability of segments compared to industry as a whole.
3. Industry sources; Chemicals Economic Handbook, Stanford Research Institute (CEH).
4. Industry sources; *Rubber World,* Feb. 1973, CEH.

WATER TREATMENT COSTS

Water treatment cost data for a typical plant in each of the technical segments were furnished to the Contractor in the form of two reports: *"Development Document for Effluent Limitations Guidelines and Standards of Performance for the Rubber Processing Industry,"* and *"Supplement A"* to this document. These documents establish a composite average-sized plant for each segment on the basis of an analysis of EPA documents, applications for Corps of Engineers Permit to Discharge, and individual company treatment data. These documents identify: the raw waste characteristics of these composite plants, the supply and volume of water used in the process, the sources of waste and wastewaters in the plants, the constituents of all wastewaters, and those contaminants which are toxic or result in taste, odor, or color in water or aquatic organisms. Given these data, the constituents of wastewaters which should be subject to effluent limitations guidelines and standards of performance were established.

The range of control and treatment technologies within each segment was also identified and assessed. This involved an evaluation of both in-plant and end-of-pipe technologies which are existent or capable of being designed for each segment. The energy requirements of each of the control and treatment technologies were estimated as well as the cost of the application of such technologies.

This information was then evaluated to determine what levels of technology constituted the "best practicable control technology currently available" (B.P.T.), the "best available technology economically achievable" (B.A.T.), and the "best available demonstrated control technology, processes, operating methods, or other alternatives for new sources" (N.S.P.S.).

We concentrated our analysis on an evaluation of those costs associated with the technologies designated as meeting the B.P.T., B.A.T., or N.S.P.S. Less costly, less effective technological alternatives were considered, but these played no role in the ultimate assessment of economic impact.

Capital Investment

In the derivation of "typical plant" investment costs, the guideline development documents include all capital expenditures required to bring the treatment or control technology into operation. The capital costs were generated on a unit basis, with the following "percent add-on" figures applied to the total unit process costs to develop the total installed capital cost requirements.

Item	Percent of Unit Process Capital Cost
Electrical	12
Piping	15
Instrumentation	8
Site Work	3
Engineering Design and Construction Supervision Fees	10
Construction Contingency	15

Since land costs vary appreciably between plant locations, land costs are not included in the estimates, and must be added on an individual case basis.

Annual Costs

Annual costs for the technological alternatives include capitalization, depreciation, operating and maintenance, and power costs. Utilizing the base investment supplied by the documents, the contractor assessed the capitalization on an individual company basis, assuming that new investments in pollution control equipment are financed by debt or equity. The ratio of debt to equity was determined by the present capitalization ratios of the companies that own these plants. Interest costs were assumed to be 10% per year on that portion of investment financed by debt.

Depreciation was calculated on a five-year straight-line basis with zero salvage value, in accordance with the Guideline Development Document. However, many companies prefer to use a ten-year basis. With a ten-year depreciation, the net effect would be a reduction in annual costs. Since none of the plants covered in this analysis are considered candidates for closing, a change to a longer depreciation period will not affect the conclusions. Annual costs would be reduced by about 25 percent. Operating costs, which include labor and supervision, chemicals, sludge hauling and disposal, insurance and taxes, were computed in the effluent guideline development documents at 2 percent of the capital cost. Maintenance cost was computed at 4 percent of capital cost. Power was based on $0.01 kw-hour for electrical power. Operating, maintenance and power costs were adjusted by the Contractor for treatment facility capacity, as is given below.

All costs were computed in terms of August 1971 dollars, which corresponds to an Engineering News Record Index (ENR) value of 1580.

Treatment Cost vs Plant Size

Table 11 lists the capital investment and operating, maintenance, and power costs associated with the typical plants for the various levels of treatment. Using as a basis the

TABLE 11

WATER EFFLUENT GUIDELINES COSTS

	Old Tire and Inner Tube Plant	New Tire and Inner Tube Plant	Emulsion Crumb Plant	Solution Crumb Plant	Latex Plant
Daily Raw Material Consumption, metric tons	205	205	–	–	–
Annual Production, metric tons	–	–	128,000	30,000	10,000
Estimated Total Effluent Flow, thousands of gallons per day	2,004	2,004	1,483	353	101
Estimated Process Effluent Flow, thousands of gallons per day	86	86	–	–	–
Total Capital Investment – B.P.T.	$ 808,000	$ 628,000	$ 2,002,000	$ 810,000	$ 637,000
Operating and Power Maintenance Cost – B.P.T.	$ 56,000	$ 45,000	$ 250,000	$ 72,000	$ 60,000
Total Capital Investment – B.A.T.	*	*	$ 2,993,000	$ 1,182,000	$ 784,000
Operating and Power Maintenance Cost – B.A.T.	*	*	$ 425,000	$ 151,000	$ 120,000

*B.P.T. and B.A.T. have identical guideline requirements for tire and tube plants.

Source: Roy F. Weston, Inc.

capital investment of the typical plant facility, the corresponding investments for other size treatment units within the range evaluated were derived as follows:

$$\text{Capital Cost of Unit X} = \text{Capital Cost of Typical Unit}\left[\frac{\text{Capacity of Unit X}}{\text{Capacity of Typical Unit}}\right]^{0.5}$$

where X is the unknown treatment facility. This relationship, which deviates from the well-known "six-tenths rule," was found to provide a better estimation of the capital costs involved in the construction of treatment facilities handling organic wastes. Appendix A details the justification for this relationship.

Likewise, an analysis of operating and maintenance costs (see Appendix A) showed them to be related to capacity of the treatment facility as follows:

$$\text{Operating and Maintenance Cost for Unit X} = \text{Operating and Maintenance Cost for Typical Unit}\left[\frac{\text{Capacity of Unit X}}{\text{Capacity of Typical Unit}}\right]^{0.58}$$

In the absence of a detailed cost breakdown, the Contractor assumed that the power costs also vary in the same manner as the operating and maintenance costs.

The relationships describing the variation of capital investment and operating, maintenance, and power costs as a function of treatment capacity were graphed for each technical segment. These graphs are shown in Figures 2 through 5. In the case of tire and tube plants, we have also related the costs to raw material consumption. In the case of synthetic rubber plants, we have related costs to annual rubber production. Raw material consumption or rubber production was considered to be *directly* proportional to water usage. Because water usage is mainly a function of water availability at low cost, and consequently varies significantly with geographic location, we believe that firms will be increasingly concerned with water conservation because of the necessity of controlling their own waste. However, we assumed a one-to-one relationship.

Plant Cost Calculations

Synthetic Rubber Plants. The estimation of waste treatment costs for synthetic rubber was complicated by the fact that many of the plants in the industry produce more than one rubber type. In addition, a number of synthetic rubber facilities are portions of large diversified plant complexes manufacturing organic chemicals as well as other products. Since, in these cases, the wastes from the synthetic rubber operations are combined and treated in a common waste treatment facility, the pollution control costs allocated to specific rubber products become a matter of corporate policy. The contractor calculated costs on the assumption that the effluents from the synthetic rubber operations were combined and treated independently of the effluents from other plant manufacturing operations.

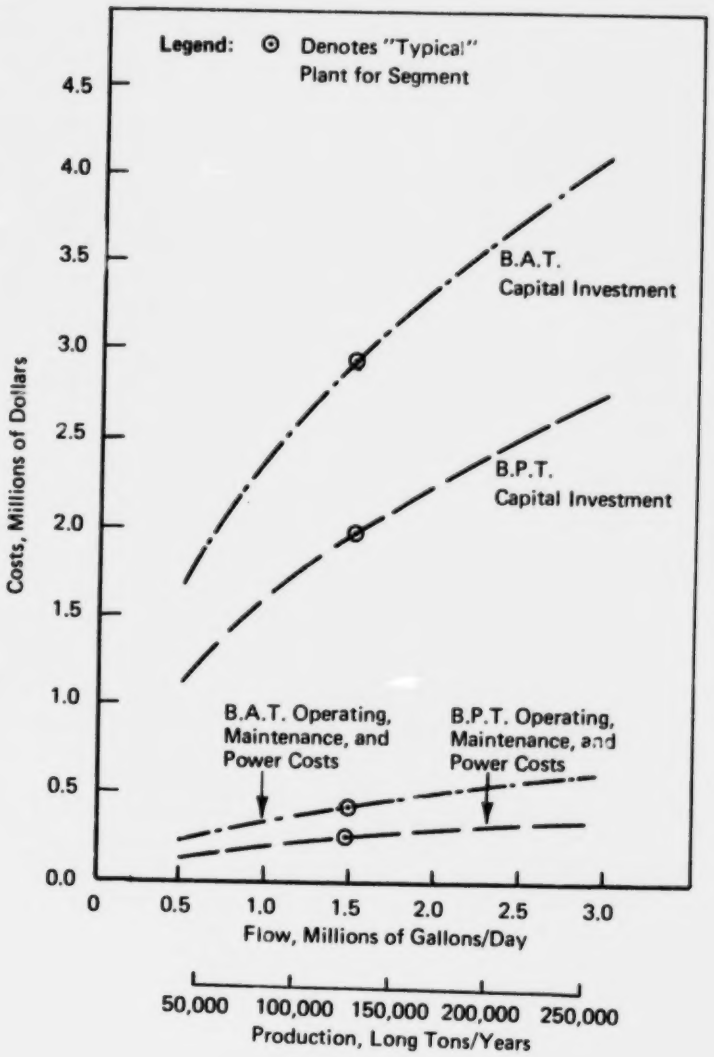

FIGURE 2 EMULSION SYNTHETIC RUBBER PLANTS: WATER TREATMENT COSTS VERSUS WASTE WATER FLOW

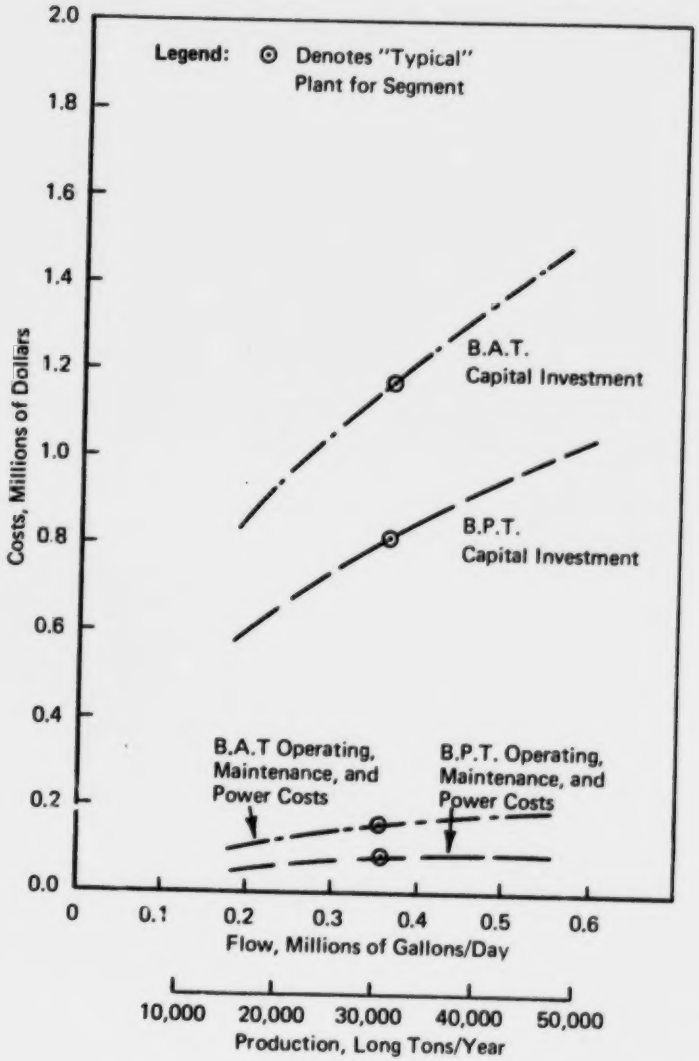

FIGURE 3 SOLUTION SYNTHETIC RUBBER PLANTS: WATER TREATMENT COSTS VERSUS WASTE WATER FLOW

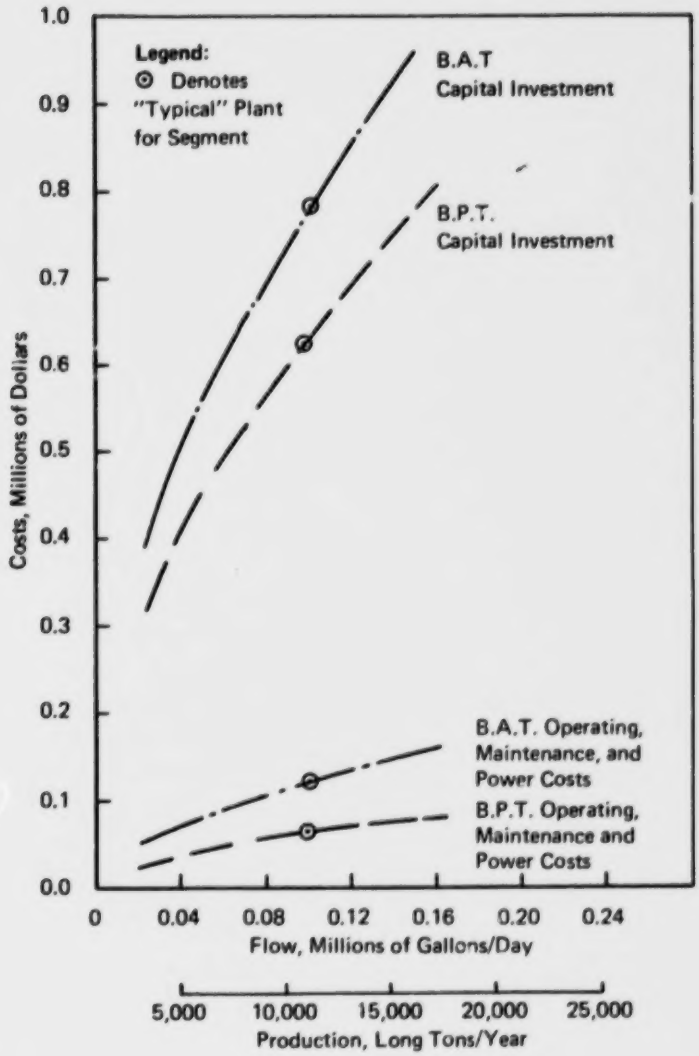

FIGURE 4 LATEX RUBBER PLANTS – WATER TREATMENT COSTS VERSUS WASTE WATER FLOW

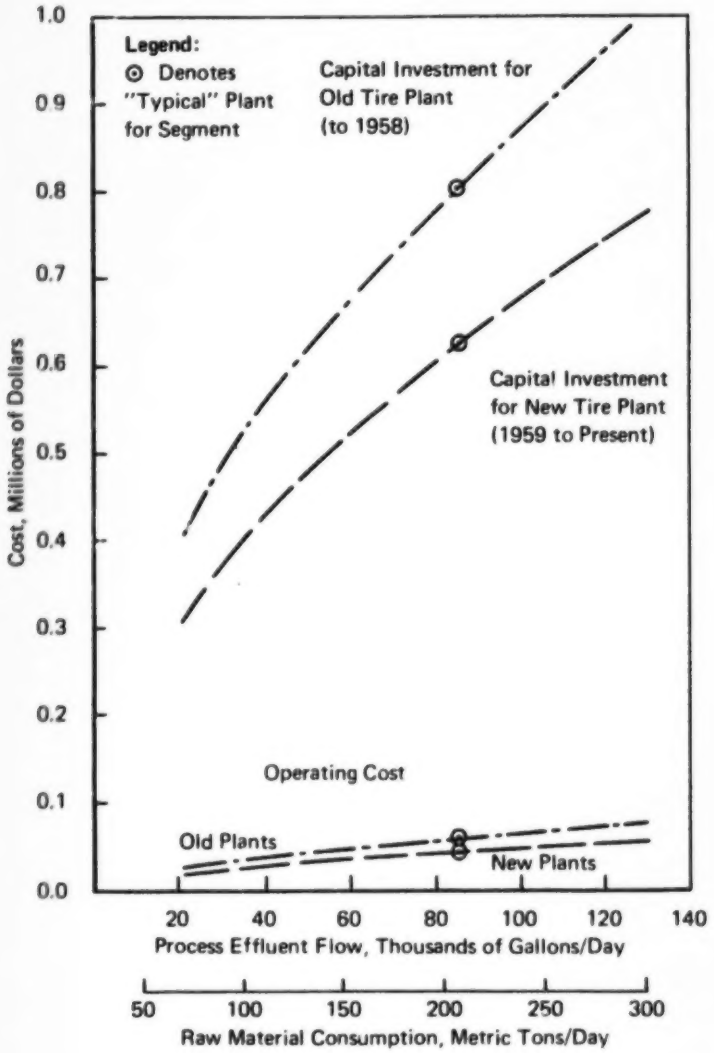

FIGURE 5 TIRE PLANTS – WATER TREATMENT COSTS VERSUS WASTE WATER FLOW

In cases where a single plant contained synthetic rubber operations producing rubber types of more than one technical segment (e.g., emulsion crumb and solution crumb, emulsion crumb and latex, etc.), costs were estimated by assuming the emulsion crumb and latex effluent streams would first be coagulated independently and then combined with the effluent from any solution polymer operations for further treatment (Table 11).

Total pollution control costs for plants were allocated back to the individual products on the basis of production capacity.

Tire and Tube Plants. Waste treatment cost estimates for specific tire and tube plants were based on the guideline documents and on data reported to us by the various companies involved. Raw material consumption was used as a basis for cost calculations in lieu of effluent discharge rates, which were typically not available to us.

ECONOMIC IMPACT ANALYSIS

Methodology

One of the key issues in determining the effect of pollution control costs on the economy is the question of how much of the cost will be passed along in the form of higher prices. In order to determine the relative price increases of the various rubber types and of tires, the contractor assumed that most of the plants studied in this report will be working at their 1972 production levels during the years 1977 through 1983, and that certain plants – e.g., those which are making EPDM – will increase their production to about 80-85% of 1972 capacity by 1977. This better capacity utilization will be due to the expanding demand for EPDM products. (Growth rate estimates for the various products are quoted on the "financial profile" tables in this report.)

The Contractor also assumed that the industry demand curves for these products are, with few exceptions, inelastic. This assumption is based on the fact that there are no substitutes for most of these rubber products (other than natural rubber) and that because of the recent devaluation of the dollar there will be little influence of imports on domestic demand for these products.

At present, most rubber and tire companies are feeling the pressure of increasing costs. During the last year labor and raw materials costs have increased, and most companies have not been able to pass along these higher costs because of various governmental price regulations. The Contractor has therefore assumed that most of the rubber and tire plants will try to pass along most pollution abatement costs to the consumer; in fact, many companies have told the contractor that they will try to do so.

Many companies have stated that they would calculate price increases by looking at the annual pollution control costs, and that they would require a return on their investments in pollution equipment of between 6% and 12% after taxes. By thus capitalizing their investments, many firms would in reality be increasing the return on equity to their stockholders, since their present average return on investment is lower than 6%.

In other words, many companies would try to become more profitable because of pollution control equipment than they would be without the pollution control equipment. The contractor considers the maximum price increase to be determined not by return on investment criteria, but by maintaining a constant return on stockholders' equity. A summary analysis of the mathematics of our methodology follows, and it relates different criteria for judging price increases.

Price Increases Under Different Assumptions

Maintain Return on Stockholders' Equity (ROE). If a company increases its price in order to maintain ROE, this price increase will be given by the following equations, assuming that production remains constant.

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Profits before pollution control:[1]

$$\pi = (pQ - c - I - d)(1-t) \tag{1}$$

Profits after pollution control:

$$\begin{aligned} \pi + \Delta\pi &= [\,(pQ + \Delta pQ) - (c + \Delta c) - (I + \Delta I) - (d + \Delta d)\,](1-t) \\ &= \pi + (\Delta pQ - \Delta c - \Delta I - \Delta d)(1-t) \end{aligned} \tag{2}$$

In order to maintain ROE:

$$\frac{\pi}{E} = \frac{\pi + \Delta\pi}{E + \Delta E} \tag{3}$$

$$\Delta E = \left(\frac{E}{D+E}\right) \text{Inv.} \tag{4}$$

N.B.

ΔI = interest rate x $\left(\frac{D}{D+E}\right)$ x Inv.

and after simplification:

$$\frac{\Delta pQ}{pQ} = \frac{\text{Inv.}}{D+E} \; \frac{1}{(1-t)} \left[\frac{\pi}{pQ}\right] + \left[\frac{\Delta c + \Delta I + \Delta D}{pQ}\right] \tag{5}$$

or

$$\text{unit price increase} = \frac{\text{Inv.}}{D+E} \text{ x [Pre-tax profit margin] + unit cost increase}$$

Maintain After-tax Profit Margin

Margin before pollution control: $\frac{\text{profits}}{\text{revenues}} = \frac{pQ - c}{pQ}$ (6)

c now denotes total costs, including taxes.

Margin after pollution control: $\frac{\text{profits}}{\text{revenues}} = \frac{(p + \Delta p)\,Q - (c + \Delta c)}{(p + \Delta p)\,Q}$ (7)

1. π = profits after taxes; p = unit price; Q = volume of production; c = total operating costs; I = interest on debt; d = depreciation; t = marginal tax rate; E = stockholders' equity; D = debt; Inv. = new investment in pollution control equipment; Δ = designates an increment in revenues or cost.

After simplification:

$$\frac{\Delta p}{p} = \frac{\Delta c}{c} \tag{8}$$

Prices increase in the same ratio as costs.

Satisfy a Specified Return on Investment (ROI)

$$\frac{\Delta p}{p} = \frac{\Delta c}{pQ} + \frac{\text{Inv.}}{(1\text{-}t) \times pQ} \times \frac{1}{\text{ROI rate}} \tag{9}$$

c now denotes total costs, including taxes.

Relationship Between the Various Assumptions

Return on Stockholders' Equity and After Tax Profit Margin

$$\text{If } \frac{1}{(1\text{-}t)} \cdot \frac{\text{Inv.}}{D+E} = \frac{\Delta p}{p} \text{ then maintaining ROE or the} \tag{10}$$

after-tax profit margin will give us the same price increase

$$\text{if } \frac{1}{(1\text{-}t)} \cdot \frac{\text{Inv.}}{D+E} > \frac{\Delta p}{p} \rightarrow \text{profit margin will decline}$$

$$\text{if } \frac{1}{(1\text{-}t)} \cdot \frac{\text{Inv.}}{D+E} < \frac{\Delta p}{p} \rightarrow \text{profit margin will increase}$$

Return on Stockholders' Equity and Return on Investment

$$\text{If } \frac{\text{profits after taxes}}{D+E} = \frac{1}{\text{ROI rate}} \tag{11}$$

then the two assumptions will give us the same price increase.

Base Data

Annual operating costs due to pollution control equipment were calculated in the following manner: Annual operating and maintenance costs were established for each of the plants in our survey by adjusting the tentative cost estimates given to us in the effluent guidelines development document. Depreciation is straight line over a period of five years. The new investments in pollution control equipment are financed by debt and equity. The ratio of debt to equity was determined by the present debt to capitalization ratios of the companies that own these plants. Interest costs are 10% per year on that portion of the investment financed by debt.

The base price for the various synthetic rubbers is based on U.S. Tariff Commission prices, industry source information, and the contractor's own internal data. Most of these prices are substantially below list price because the contractor has taken in account the discounts given by manufacturers. Also, substantial quantities of many synthetic rubbers are sold, not on the open market, but internally within the large tire and rubber manufacturers.

The average price of tires (passenger, truck and bus) was established using Bureau of Domestic Commerce data industry sources and estimates. The unit value of a passenger tire in 1972 was $14.43 whereas the average price of all tires was $21.24.

Tables 12 through 15 on the following pages summarize product sales, B.P.T., B.A.T. and B.P.T. + B.A.T. investment and annual costs for the various industry segments studied in this report. The last two columns of these tables indicate what the expected annual costs as a percentage of sales will be both for each segment on average, and the range of this ratio for plants in each segment.

Tables 16, 17, and 18 summarize investment and annual costs as a percent of sales for various synthetic rubber and tire companies both for B.P.T. and B.A.T. pollution abatement levels.

Most latex plants belong to large corporations and are but small contributors to overall profits. Due to limited data available on the SBR latex industry, the predictions of how pollution control costs will affect this segment of the synthetic rubber industry, are based on evaluations of 26 percent of the plants.

Tables 19 and 22 present the available data. The Contractor also believes that the same conclusions that have been drawn for the synthetic rubber industry also apply to SBR latex, although further study would be necessary to positively evaluate this opinion.

Price Effects

The range of calculated price increases by plant for each of the rubber types and for tires is given in Table 20 and 21. This range is based not only on the effluent guideline document figures, but also on the amount each plant has already invested to attain B.P.T. pollution standards. The probable price increase for each rubber type and for tires was computed by taking into consideration the range of possible price increases, the relative position of the various plants and companies within the industry, whether or not there are any price leaders, and the relative growth of this industry as well as its market position vis-à-vis other rubber types and imports.

Our unit price increases were calculated using formula (5) in the methodology. Unit cost increases have been summarized in Tables 12 through 15. The term Inv/D+E (pre-tax profit margin) varied between 0.1 and 0.3% for synthetic rubber manufacturers and between 0.06 and 0.44% for tire and tube manufacturers.

TABLE 12

B.P.T. COSTS
(based on effluent guideline document data)

Product	Process	No. of Plants in U.S.A.	No. of Plants in Sample	Total Investment (millions of $)	Average Investment per Plant	Total Annualized Costs (millions of $)	Average Annualized Cost per Plant	Total Product Sales (millions of $)	Total Annualized Costs/ Total Sales (%)	Plants Range (%'s)
Butyl	solution	3	3	3.0	1.0	0.950	0.320	72	1.3	1.2-1.5
E.P.D.M.	solution	5	5	3.5	0.7	1.100	0.220	90	1.2	0.7-1.5
Neoprene	emulsion	3	3	4.0	1.3	1.300	0.430	142	0.9	0.7-1.2
Nitrile	emulsion & latex	9	8	4.5	0.6	1.500	0.210	93	1.6	0.5-2.4
Polybutadiene	emulsion	1	1	6.8	1.0	2.400	0.340	144	1.7	1.2-2.2
	solution	6	6							
Polyisoprene	solution	2	2	1.4	0.7	0.470	0.230	51	0.9	0.9
S.B.R	emulsion & solution	11	11	19.5	1.8	7.400	0.670	406	1.8	1.3-4.7
Tires & Tubes	–	56	48	35.2	0.7	14.400	0.300	5,069	0.3	0.2-0.5

TABLE 13

B.P.T. COSTS
(based on industry incremental costs)

Product	Process	No. of Plants in U.S.A.	No. of Plants in Sample	Total Investment (millions of $)	Average Investment per Plant	Total Annualized Costs (millions of $)	Average Annualized Cost per Plant	Total Product Sales (millions of $)	Total Annualized Costs/ Total Sales (%)	Plants Range (%'s)
Butyl	solution	3	2	2.7	1.3	0.850	0.430	53	1.6	1.2-2.3
E.P.D.M.	solution	5	5	2.1	0.4	0.730	0.150	90	0.8	0 -2.1
Neoprene	emulsion	3	3	4.30	1.4	1.600	0.530	142	1.1	0.3-1.5
Nitrile	emulsion & latex	9	8	2.6	0.3	0.840	0.110	93	0.9	0 -3.5
Polybutadiene	emulsion	1	1	1.8	0.3	0.700	0.120	121	0.6	0 -1.4
	solution	6	5							
Polyisoprene	solution	2	2	0.4	0.2	0.170	0.090	51	0.3	0 -0.7
S.B.R.	emulsion & solution	11	10	8.6	0.9	3.050	0.310	386	0.8	0 -7.4
Tires & Tubes	–	56	40	31.5	0.8	12.560	0.310	4,681	0.3	0.2-0.4

TABLE 14

B.A.T. COSTS
(based on effluent guideline document data)

Product	No. of Plants in U.S.A.	No. of Plants in Sample	Total Investment (millions of $)	Average Investment per Plant	Total Annualized Costs (millions of $)	Average Annualized Cost per Plant	Total Product Sales (millions of $)	Total Annualized Costs/ Total Sales (%)	Plants Range (%'s)
Butyl	3	3	1.4	0.5	0.610	0.200	72	0.9	0.7-1.0
E.P.D.M.	5	5	1.6	0.3	0.580	0.120	90	0.6	0.4-0.9
Neoprene	3	3	2.0	0.7	0.750	0.250	142	0.5	0.4-0.7
Nitrile	9	8	1.1	0.1	0.700	0.090	93	0.8	0.2-1.1
Polybutadiene	7	7	3.2	0.5	1.500	0.210	144	1.0	0.8-1.5
Polyisoprene	2	2	0.6	0.3	0.300	0.150	51	0.6	0.6
SBR	11	11	10.2	0.9	4.000	0.360	406	1.0	0.5-2.6
Tires & Tubes	B.A.T. standards are the same as B.P.T. standards								

TABLE 15

B.P.T. COSTS
(industry response)
AND
B.A.T. COSTS
(effluent guideline document data)

Product	No. of Plants in U.S.A.	No. of Plants in Sample	Total Investment (millions of $)	Average Investment per Plant	Total Annualized Costs (millions of $)	Average Annualized Cost per Plant	Total Product Sales (millions of $)	Total Annualized Costs/ Total Sales (%)	Plants Range (%'s)
Butyl	3	2	3.6	1.8	0.740	0.370	53	1.4	1.2-1.7
E.P.D.M.	5	5	3.7	0.7	1.010	0.200	90	1.1	0.4-1.4
Neoprene	3	3	6.4	2.1	1.700	0.570	142	1.2	1.1-1.4
Nitrile	9	8	3.6	0.5	1.120	0.140	93	1.2	0.2-2.4
Polybutadiene	7	6	4.4	0.7	1.600	0.270	121	1.3	0.9-1.9
Polyisoprene	2	2	1.0	0.5	0.330	0.150	51	0.6	0.6-0.7
SBR	11	10	18.8	1.9	5.000	0.500	386	1.3	0.5-4.7
Tires & Tubes	B.A.T. standards are the same as B.P.T. standards								

TABLE 16

SYNTHETIC RUBBER COMPANIES

Company*	Investment as a Percent of Sales		Annual Costs as a Percent of Sales	
	B.P.T.	B.A.T.	B.P.T.	B.A.T.
1	9.9	2.5	3.1	1.2
2	3.0	1.4	0.6	0.3
3	5.1	1.8	1.7	0.8
4	2.2	1.6	0.7	1.2
5	3.0	2.6	1.1	1.1
6	4.3	2.5	2.1	1.0
7	1.7	2.1	1.0	1.0
8	0.8	2.5	0.3	1.2
9	0.4	2.7	0.1	1.1
10	0	3.1	0	0.7
11	0	2.4	0	0.5
12	0	3.3	0	1.3

*Ranked by size of B.P.T. investment.

TABLE 17

TIRES AND TUBES COMPANIES

Company	Investment/Sales	Cost/Sales
I	0.7	0.2
II	0.8	0.2
III	1.0	0.3
IV	1.3	0.4
V	0.5	0.2

TABLE 18

SYNTHETIC RUBBER + TIRES AND TUBES

Company	B.P.T. Investment (millions of $)	B.P.T. Investment/Sales	B.A.T. Investment/Sales	B.P.T. Annual Cost/Sales	B.A.T. Annual Cost/Sales
A	13.6	0.9	0.2	0.3	0.1
B	12.6	1.0	0.2	0.3	0.1
C	10.0	0.9	0.1	0.4	0.1
D	6.0	1.2	0.2	0.3	0.1
E	5.7	0.8	0.4	0.2	0.2
F	4.1	3.0	1.4	0.6	0.3
G	3.5	5.1	1.8	1.7	0.8
H	2.0	4.3	2.5	2.1	1.0
I	1.5	1.7	2.1	1.0	1.0
J	0.3	0.8	2.5	0.27	1.2
K	0.2	0.4	2.7	0.1	1.1
L	0	0	2.4	0	0.5

TABLE 19

LATEX

Product	Process	No. of Plants in U.S.A.	No. of Plants in Sample	Sample Plants Production as a % of 1972 Total Production	Total Investment (millions of $)	Average Investment per Plant	Total Annualized Costs (millions of $)	Average Annualized Cost per Plants	Product Sales (millions of $)	Total Annualized Costs/ Total Sales (%)	Plant Range (%'s)
					B.P.T. Costs (based on effluent guideline document data)						
S.B.R.	Latex	23	6	70%	3.6	0.6	1.21	0.20	37.3	3.2	1.55-2
					B.P.T. Costs (based on industry incremental costs)						
S.B.R.	Latex	23	3	38%	1.0	0.3	0.38	0.13	20.2	1.9	0.5-2
					B.A.T. Costs (based on effluent guideline data)						
S.B.R.	Latex	23	6	70%	1.8	0.3	0.56	0.19	37.3	1.5	0.42-4
					B.P.T. Costs (industry response) and B.A.T. Costs (effluent guideline document)						
S.B.R.	Latex	23	3	38%	1.4	0.5	41	14	20.2	2.0	0.44-8

TABLE 20

SYNTHETIC RUBBER (SIC 2822)

	Price Effects				Other Effects	
	B.P.T.		B.A.T.			
	Range[1]	Probable Effect	Range[1]	Probable Effect	Price Effect on Tires	Plant Shutdown
Butyl	0-1.6%	< 1.2%	0-1.6%	< 1.2%		None
E.P.D.M.	0-2.3%	< 0.5%	0-1.6%	< 0.5%	No	None
Neoprene	0-1.6%	1%-1.5%	0-1.7%	1%-1.5%		None
Nitrile	0-3%	< 0.6%	0-2.5%	< 0.6%		None
Polybutadiene	0-1.5%	1%-1.5%	0-2.0%	1%-1.5%	Yes	None
Polyisoprene	0-0.8%	< 0.6%	0-0.8%	< 0.6%	No[2]	None
S.B.R. Crumb	0-7.4%	< 0.8%	0-4.7%	< 0.8%	Yes	None

1. Based on E.P.A. tentative costs and industry response.
2. Polyisoprene competes with natural rubber, the price of which can be expected to be higher in the U.S.A. than that of polyisoprene in the coming 5 years.

TABLE 21

TIRES AND INNER TUBES (SIC 3011)

Price Effects			Other Effects	
Based on Revised E.P.A. Figures	Based on Industry Response	Probable Effect	Plant Shutdown	Other
0.3-0.6%	0.45-0.6%	<0.45%	None	Lowering of profit margins of small tire manufacturers relative to the large integrated companies

TABLE 22

LATEX PRICE EFFECTS

B.P.T.		B.A.T.	
Range[2]	Probable Effect	Range[2]	Probable Effect
0-5.4	<2.1	0.6-5.0	<2.2

1. The validity of these price effects is limited due to the small size (3) of the sample.
2. Based on E.P.A. tentative costs and industry response.

The price increases that could be expected to attain B.A.T. pollution control standards for the synthetic rubbers are based on 1972 prices. They were computed by taking into consideration the incremental annual costs over and above B.P.T. costs. However, by 1983, companies will have fully depreciated their 1977 pollution control equipment. This is the basic reason for which we find in Table 20 that the price increases due to attaining B.A.T. standards will not be higher than those necessitated for attaining B.P.T. standards.

Secondary Effects

Synthetic Rubber Industry (SIC #2822). We do not consider that there will be any major changes in this industry because of the small changes in the relative prices of the synthetic rubbers. However, synthetic rubbers are a major component of tires (SIC #3011), and therefore we expect that tires will increase in price not only because of the costs incurred in controlling the pollution of tire plants, but also because of the increased cost in synthetic rubbers due to pollution control.

If the rubber content of a tire is approximately 25 percent of the total value of a tire then we can expect a 1 percent increase in rubber raw material cost and therefore a tire cost increase of 0.25 percent.

Tire and Tube Industry (SIC #3011). Within the tire industry there may be certain small changes. Because of plant size, age and already existing pollution abatement equipment, the large companies will increase their prices relatively less than the small companies would like to increase their prices. In other words, the profitability of the smaller firms will decrease relative to the larger firms. (It should be noted that this effect is not due to our method of calculating price increases: in equation 5, the term "Investment Over Debt plus Equity," was held constant and equal to 0.02 for all tire plants.)

Akron plants have a special problem of land availability that must be solved to provide adequate space for equipment if they cannot depend on the municipal system.

Financial Effects (SIC #2822 and SIC #3011)

If prices are raised in order to maintain the return on equity for the various companies and plants, there should not be any major financial effects for the industry as a whole. However, certain of the smaller firms would like to raise their prices more than their larger competitors would. In other words, their profit margins will decrease as compared to that of their competitors. In the long run this could slightly change the structure of these industries.

Capital Availability. Of all the companies that we interviewed for this study, we consider that there is only one that could have problems raising the necessary capital in order to meet pollution guidelines. However, we feel that this company will be in a much stronger financial position by 1976 and that it should not have any problems at that time. Our survey covered all the major tire manufacturers. It is possible that some of the smaller companies will have capital availability problems.

Production Curtailment

Synthetic Rubber. We do not expect to see any production curtailment in any of the synthetic rubber plants because of the new guidelines.

Tires and Tubes. Many tire manufacturers feel that they would have to shut down their plants temporarily in order to segregate their process effluent lines from their other effluent lines. We have no way of evaluating the validity of these statements nor what their true economic consequences may be.

Plant Closings

Synthetic Rubber (SIC #2822). On the basis of our data and industry response we do not expect any plant to be closed down.

Tires and Tubes (SIC #3011). On the basis of our data and industry response we do not expect any plant to be closed down.

Community Impacts

Synthetic Rubber (SIC #2822). None

Tires and Tubes (SIC #3011). If plants have to be temporarily shut down to segregate process effluent lines from other lines, there would probably be lay-offs of workers in the plants thus affected. It is presently impossible to evaluate such effects.

Industry Growth (SIC #2822 and SIC #3011)

We do not feel that the economic effects of the B.P.T. or of the B.A.T., N.S.P.S. guidelines will adversely affect the growth or the growth potential of either the synthetic rubber or the tire industries. Industry spokesmen have said that their plant expansion decisions will not be affected by the new guidelines.

International Trade Effects (SIC #2822 and SIC #3011)

The recent devaluations of the U.S. dollar have made U.S. produced tires and synthetic rubbers much more competitive on the international scene. The relatively small increase in prices required to meet pollution guidelines should hardly change this position. The price of natural rubber imported into the United States has increased substantially more than, for instance, polyisoprene, its synthetic substitute. Even if there were large surpluses of synthetic rubbers in other countries, it is doubtful that foreign manufacturers could dump their products on the U.S. market at a competitive price. However, we must qualify these statements by saying it is impossible to know what the position of the United States dollar will be in 1977 and thereafter relative to other currencies.

Limits of the Analysis

When interpreting the findings of this study, it is important to be aware of the nature and limitations of the cost data specifically as regards B.P.T. guidelines and the key assumptions which were used.

The investment costs of pollution control equipment were defined to include the direct incremental investment required to attain environmental standards. The operating costs for pollution control equipment were defined to be incremental costs.

The establishment of the pollution standards as well as the determination of the cost basis for investment and operating costs was provided to us in the effluent guideline development document. In the appendix to our report we have listed the cost data as well as the scale-up factors we used in estimating the investment and operating costs for plants with capacities other than those on which the data is based. Additional data input to our study was provided through field interviews with and questionnaires to industry representatives. This data was used to supplement the information.

Only water pollution abatement costs associated with Federal standards were considered; and these costs were assumed to be independent of air and solid waste control requirements.

The calculated price effects on the various rubber types and tires of the pollution guidelines (B.A.T. and B.P.T.) are maximum expected price increases. Although we anticipate price increases, certain companies and certain plants, because they already meet B.P.T. guidelines, may not increase their prices at all. Other companies within the industry may follow suit.

APPENDIX A

ESTIMATION OF PLANT COSTS FOR EFFLUENT GUIDELINES

The typical plant costs given in the effluent guidelines development document do not provide any information indicating how the costs vary as a function of treatment facility capacity. At the recommendation of Dr. David Day of Roy F. Weston, Inc., we utilized the data provided in the "Development Document for Effluent Limitations Guidelines and Standards of Performance for the Organic Chemicals Industry, Supplemental Data." The pollution control technology described in this document was considered to be comparable to that utilized in treating the wastes of the rubber processing industry.

In Figures 6 and 7 are plotted the appropriate data points given in the organic chemicals document. Figure 6 shows that a curve generated according to the equation

$$\text{Capital Cost of Plant X} \quad \text{Capital Cost of Base Plant} \times \left[\frac{\text{Waste water flow of Plant X}}{\text{Waste water flow of Base Plant}}\right]^{0.5}$$

(where X designates an unknown plant) correlates very well with the actual data.

Likewise, Figure 7 shows that the operating, maintenance, and power costs (designated as "Operating Costs" in the figure) vary as a function of capacity according to

$$\text{Operating, Maintenance, and Power Costs of Plant X} = \text{Operating, Maintenance, and Power Costs of Base Plant} \times \left[\frac{\text{Waste water flow of Plant X}}{\text{Waste water flow of Base Plant}}\right]^{0.58}$$

Although specific categories of treatment were chosen for the purposes of illustration in these figures, the equations described above were found to apply for all the categories in the organic chemicals document, and were found to provide reasonable cost estimates for the rubber processing industries. Therefore, the Contractor used these relationships for generating pollution control costs for specific plants.

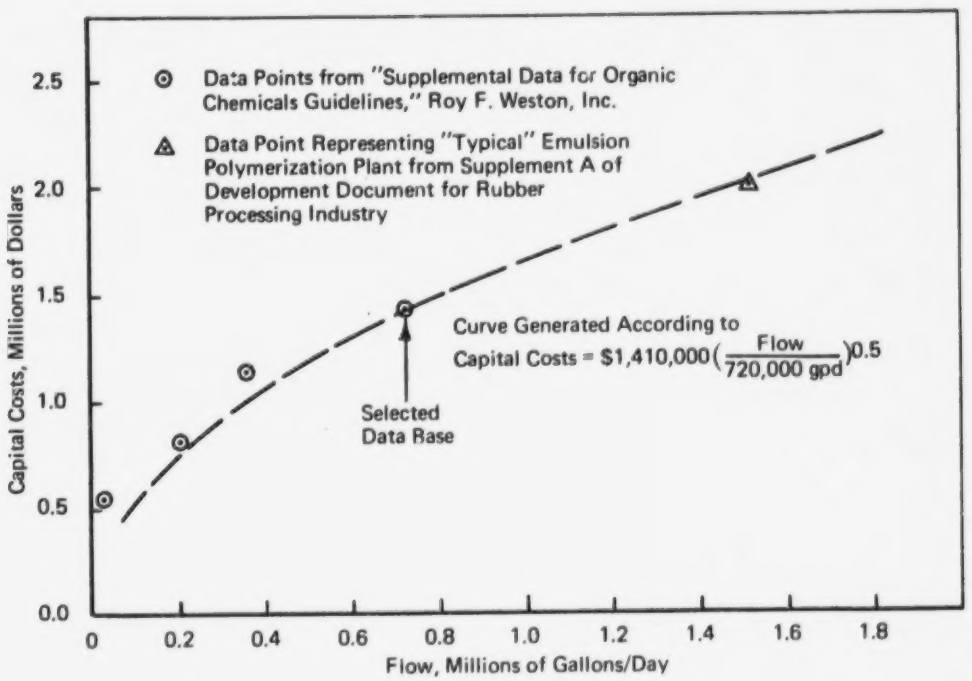

FIGURE 6 CAPITAL COST VERSUS WASTE WATER FLOW

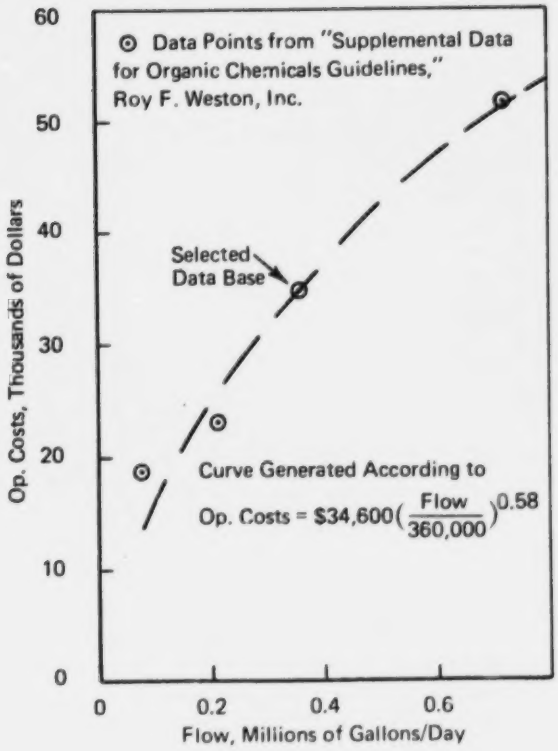

FIGURE 7 B.P.T. – YEARLY OPERATIONAL COSTS VERSUS WASTE WATER FLOW

APPENDIX B

SAMPLE CALCULATION OF SYNTHETIC RUBBER PLANT POLLUTION CONTROL COSTS

The annual B.P.T. pollution control costs, for example, of a plant with the hypothetical production of 100,000 long tons of emulsion crumb, 40,000 long tons of solution crumb, and 8,000 long tons of latex are calculated as follows.

Through reference to the information summarized in Figures 2, 3, and 4, we would generate

		B.P.T. Investment	B.P.T. Operating, Maintenance & Power Costs
100,000 lt	Emulsion crumb	$1,760,000	$215,000
8,000 lt	Latex	570,000	53,000

And these would be the cost estimates of each if these effluent streams were to be fully treated independently. However, we assume that after pretreatment to chemically coagulate the suspended rubber in these streams they are then combined with the effluent stream from the solution crumb operation (which does not have to be chemically coagulated) for further treatment – thus benefitting from the economies inherent in treating the combined effluents. Thus, instead of sizing the solution crumb waste treatment facility to handle the effluent represented by 40,000 long tons of production, we size it to handle the load represented by 100,000 + 8,000 + 40,000 = 148,000 long tons.

From Figure 3 we find the costs associated with such a facility are

Investment	Operating, Maintenance, and Power Costs
$1,780,000	$180,000

We then apportion the various costs developed above according to actual effluent load, as follows:

$$\text{Total Plant Investment} = \underbrace{\frac{100,000}{148,000} \times \$1,760,000}_{\text{Emulsion Crumb Treatment}} + \underbrace{\frac{40,000}{148,000}\ \$1,780,000}_{\text{Solution Crumb Treatment}}$$

$$+ \underbrace{\frac{8,000}{148,000} \times \$570,000}_{\text{Latex Treatment}}$$

$$= \$1,700,000$$

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Likewise,

Total Operating, Maintenance, and Power Costs (O.M.P.) =

$$\frac{100{,}000}{148{,}000} \times \$215{,}000 + \frac{40{,}000}{148{,}000} \times \$180{,}000$$

$$+ \frac{8{,}000}{148{,}000} \times \$53{,}000 = \$197{,}000$$

A comparison of the costs generated by this technique with those generated by assuming that each of the effluent streams at the plant are treated in separate facilities is given below:

	Cost Apportionment by Assuming Combined Effluent Treatment		Cost Apportionment by Assuming Separate Treatment	
	Investment	O.M.P.	Investment	O.M.P.
Emulsion crumb	$1,190,000	$145,000	$1,760,000	$215,000
Solution crumb	480,000	49,000	935,000	85,000
Latex	30,800	2,900	570,000	53,000
Total Plant Cost	$1,700,800	$196,900	$3,265,000	$353,000

On the basis of our discussions with industry spokesmen, our assumption of the use of combined treatment is valid, and, as a consequence, we believe our cost estimates based on this assumption are more accurate indications of the costs that will actually be incurred.